OIPE JC34
APR 17 2003
PATENT & TRADEMARK OFFICE

Docket No.: 49959-013 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

RECEIVED
NOV 04 2003
Technology Center 2600

In re Application of :
:
Ariel BEN-PORATH, et al. :
:
Serial No.: 09/111,454 : Group Art Unit: 2623
:
Filed: July 8, 1998 : Examiner: V. Bali
:

For: AUTOMATIC DEFECT CLASSIFICATION WITH INVARIANT CORE CLASSES

APPEAL BRIEF

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

This Appeal Brief is submitted in support of the Notice of Appeal filed January 22, 2003.

I. REAL PARTY IN INTEREST

The real Party In Interest is Applied Materials, Inc.

II. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any related appeals and interferences.

III. STATUS OF CLAIMS

Claims 1-3, 6-20, 23-38 and 40-63 are pending in the application. Claims 9-17, 26-34 and 49-60 have been withdrawn from consideration. It is from the rejection of claims 1-3, 6-8, 18-20, 23-25, 35-38, 40-48 and 61-63 that this Appeal is taken.

04/18/2003 SFELEKE1 00000042 500417 09111454
02 FC:1402 320.00 CH

IV. STATUS OF AMENDMENTS

There are no outstanding amendments.

V. SUMMARY OF INVENTION

The thrust of the present invention is directed to a method and apparatus for automatically classifying a defect on the surface of a semiconductor wafer into one of a plurality of invariant (i.e., standardized) core classes after inspection with, for example, a scanning electron microscope (SEM) and/or an optical inspection tool (see Application page 6, line 27 to page 7, line 2). The invariant core classes of defects can include a missing pattern on the surface, an extra pattern on the surface, a deformed pattern on the surface, a particle on the surface, a particle embedded in the surface, a particle and a deformed pattern on the surface, or craters and microscratches on the surface (page 7, lines 6-12). The defect may be further classified into one or more subclasses of one of the invariant core classes, the subclasses being of arbitrarily defined defects defined by the user (page 7, lines 2-4). As the defects are classified, counts are maintained of the number of occurrences of each type of defect, and an alarm is raised if the defect count in a particular class exceeds a predetermined level (page 8, lines 11-13).

Defects are accurately and reliably classified and monitored using the present apparatus and methodology, thereby enabling early detection and cure of processing problems (page 8, lines 13-15). All defects are classified by the present methodology into one of a predetermined number of invariant core classes (page 6, line 27 to page 7, line 2). The present invention thereby provides a standardized set of defect classes, which are readily correlated to the causes of defects (page 6, lines 23-26). Moreover, since the defect classes are standardized rather than user-specific, the present apparatus and methodology requires a lesser number of defect images

to be obtained for each defect class prior to becoming operational (page 22, lines 1-10). Consequently, the present invention can be easily utilized during start-up and ramp-up of a production line (page 22, lines 10-12).

VI. ISSUES

A. Whether claims 1-3, 6-8, 18-20, 23-25, 37, 38, 40-42 and 61-63 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent 5,801,965 (Takagi) in view of U.S. Patent 5,814,829 (Broude) and further in view of U.S. Patent 4,849,901 (Shimizu).

B. Whether claims 35, 36 and 43-45 are unpatentable under 35 U.S.C. § 103(a) over Takagi, Broude and Shimizu and further in view of U.S. Patent 5,591,971 (Shahar).

C. Whether claims 46 and 47 are unpatentable under 35 U.S.C. § 103(a) over Takagi in view of Shahar.

D. Whether claim 48 is unpatentable under 35 U.S.C. § 103(a) over Takagi and Shahar and further in view of U.S. Patent 5,960,106 (Tsuchiya).

VII. GROUPING OF CLAIMS

The appealed claims 1, 2, 3, 7, 8, 18-20, 24, 25, 37, 38, 40, 42, and 61-63 stand or fall together. The appealed claims 6, 23 and 41 stand or fall together. The appealed claims 35, 36, and 43-45 stand or fall together. The appealed claims 46 and 47 stand or fall together. The appealed claim 48 stands or falls separately.

VIII. THE ARGUMENT

A. The Applied Prior Art

1. Tagaki

The Tagaki reference relates to a method and apparatus for inspecting a product for defects and classifying the defects. In Tagaki, defect classes are changeable (i.e., the number of classes are expandable) depending on how the defects fit into a constantly evolving classification model. If a defect falls outside or in between "clusters" in the classification space of Tagaki's classification model, a new cluster is made, and/or the operator is asked to classify the defect. Absent is the claimed teaching of classifying defects into invariant core classes.

2. Broude

Broude relates to a photolithographic mask (or "reticle") inspection system wherein when a threshold number of reticle defects of a particular size at a particular location is exceeded, the inspection is interrupted and the operator informed, so that time is not wasted continuing inspection of a low-quality reticle. Absent is the claimed teaching of classifying defects into invariant core classes.

3. Shimizu

Shimizu relates to an apparatus for inspecting a substrate for flatness. Shimizu teaches sounding an alarm and notifying the operator if the number of chips having poor flatness exceeds a predetermined number. Absent is the claimed teaching of classifying defects into invariant core classes.

4. Shahar

Shahar relates to an SEM inspection system having multiple electron detectors. Absent is the claimed teaching of classifying defects into invariant core classes.

5. <u>Tsuchiya</u>

Tsuchiya relates to a method and apparatus for inspecting patterns formed on glass. Absent is the claimed teaching of classifying defects into invariant core classes.

B. <u>The Issues Addressed</u>

1. <u>The Examiner Did Not Establish a ***Prima Facie*** Case of Obviousness Under 35 U.S.C. § 103.</u>

The initial burden of establishing a ***prima facie*** basis to deny patentability to a claimed invention under any statutory provision always rests upon the Examiner. ***In re Mayne***, 104 F.3d 1339, 41 USPQ2d 1451 (Fed.Cir. 1997); ***In re Deuel***, 51 F.3d 1552, 34 USPQ2d 1210 (Fed.Cir. 1995); ***In re Bell***, 991 F.2d 781, 26 USPQ2d 1529 (Fed.Cir. 1993; ***In re Oetiker***, 977 F.2d 1443, 24 USPQ2d 1443 (Fed.Cir. 1992). In rejecting a claim under 35 U.S.C. § 103, the Examiner is required to provide a factual basis to support the obviousness conclusion. ***In re Warner***, 379 F.2d 1011, 154 USPQ 173 (CCPA 1967); ***In re Lunsford***, 357 F.2d 385, 148 USPQ 721 (CCPA 1966); ***In re Freed***, 425 F.2d 785, 165 USPQ 570 (CCPA 1970). The Examiner is required to show that all the claim limitations are taught or suggested by the references. ***In re Royka***, 490 F.2d 981, 180 USPQ 580 (CCPA 1974); ***In re Wilson***, 424 F.2d 1382, 165 USPQ 494 (CCPA 1970). In addition, the Examiner is obliged to explain how and why one having ordinary skill in the art would have been realistically motivated to combine the applied references to arrive at the claimed invention. ***In re Ochiai***, 71 F.3d 565, 37 USPQ2d 1127 (Fed.Cir 1991); ***In re Deuel***, ***supra***. In establishing the requisite motivation, it has been consistently held that the Examiner must show an objective teaching in the art that would have motivated one skilled in the art to modify the cited reference to yield the claimed invention. ***In re Jones***, 958 F.2d 347, 21

USPQ2d 1941 (Fed.Cir. 1992); ***In re Mills***, 16 USPQ2d 1430 (Fed.Cir. 1990); ***In re Fine***, 837 F.2d 1071, 5 USPQ2d 1596 (Fed.Cir. 1988).

a. <u>Claims 1-3, 6-8, 18-20, 23-25, 37, 38, 40-42 and 61-63 are not rendered obvious under 35 U.S.C. §103(a) by Tagaki in view of Broude and Shimizu, because the Examiner has not shown that all the limitations of those claims are taught or suggested by the references, and has not shown an objective teaching that would have motivated a skilled artisan to combine the references to yield the inventions of these claims.</u>

Regarding the obviousness rejection of independent claims 1, 18, 37, and 61-63 based on Tagaki, Broude and Shimizu, none of these references teaches or suggests classifying each detected defect into one of a predetermined number of invariant core classes, as required by claims 1, 18, 37 and 61-63. A sample invariant classification scheme according to the present invention is illustrated at Fig. 1 of the application, showing seven invariant core classes 3A-3E, into which all defects are classified. This invariant classification scheme is an important feature of the present invention because it enables standardization of defect classification, resulting in ready determination of the causes of defects compared to prior art inspection techniques, and the ability to use the present invention upon start-up and ramp-up of production.

It is contended by the Examiner that Tagaki teaches classifying defects into invariant core classes, as claimed. However, this is not an accurate characterization of Tagaki's teaching. As explained at col. 12:3-26 of Tagaki, its defect classes are changed (i.e., the number of classes are expanded) depending on how the defects fit into a constantly evolving classification model. If a defect falls outside or in between "clusters" in the classification space of Tagaki's classification model, a new cluster is made, and/or the operator is asked to classify the defect. Thus, Tagaki's classification scheme is the opposite of the claimed invariant classification technique. It is

infinitely variable, allowing a new category to be made for each defect, if necessary. Tagaki is analogous to the prior art defect classification schemes, discussed at pages 2-3 of the present application, which lack standardized defect classes. In contrast, the claimed invention classifies each defect into one of a very limited number of invariant core classes.

It is further contended that since Tagaki teaches using standard classification models to classify defects, at any given time Tagaki is teaching classifying defects into one of a predetermined number of invariant core classes, as claimed. The Examiner is contending the claim term "invariant core classes" covers the standard but changeable defect classes taught by Tagaki. Applicants submit that this is an unreasonably broad interpretation of the language of independent claims 1, 18, 37, and 61-63, since it effectively renders the term "invariant" meaningless as used in those claims. The Examiner is improperly eliminating (or "reading out") the term "invariant" from the phrase "invariant core classes" as used in the claims by giving it an interpretation so broad that it is contrary to the term's ordinary meaning.

It is well-established that the words of a claim must be given their plain meaning unless they are otherwise defined in the specification (see MPEP § 2111.01). In the present case, the plain meaning of the word invariant is "unvarying" or "constant". See, e.g., ***Random House Webster's Unabridged Dictionary***, Second Edition, Random House 1998. Further, the specification does not contradict the plain meaning or indicate any special meaning. Thus, in light of the plain meaning of "invariant", it is not reasonable to interpret the claimed "invariant core classes" as including Tagaki's changeable classes. It is not reasonable to equate something explicitly described as invariant or constant, such as the claimed invariant core classes, to something that is changeable, such as Tagaki's defect classifications.

While one skilled in the art may consider Tagaki's classification models (see Tagaki Fig.

3, reference numeral 352) to be "core classes" at any given time, one skilled in the art would not consider them to be *invariant* core classes, as claimed, since they are taught by Tagaki to be subject to change over time. In other words, Tagaki teaches *variant* core classes, rather than *invariant* core classes, as claimed. See col. 11:65 to col. 12:22 of Tagaki. The language of independent claims 1, 18, 37 and 61-63 clearly distinguishes the claimed invention over Tagaki, if the claim terms are given their plain meaning, as required by the law.

Since none of the cited references teaches or suggests the step of classifying each defect into one of a predetermined number of invariant core classes, as required by independent claims 1, 18, 61 and 62, or teaches or suggests the processor of independent claim 37 and 62 for performing this step, no combination of the references, however made, could yield the invention of claims 1, 18, 37, or 61-63 and it would not have been obvious to modify any Tagaki/Broude/Shimizu combination to yield the claimed invention.

Further regarding claims 1, 18 and 37, even assuming, ***arguendo***, that the references taught all the recited features of claims 1, 18, and 37, it would not have been obvious to combine Tagaki and Broude as the Examiner suggests. The Examiner contends that it would have been obvious to combine Takagi's defect inspection and classification technique with Broude's teaching of inspecting for defects, mapping and counting the defects and generating a signal when a threshold number of defects of a particular size and/or at a particular location are found, to thereby yield the inventions of claims 1, 18, and 37.

Applicants disagree. The Examiner has not provided an objective teaching in either reference that would have motivated a skilled artisan to incorporate Broude's teaching into Takagi's system, because none exists. The purpose of Takagi's semiconductor device defect classification system is to extract feature data of the defects based on their classification, feed

back this information to improve the automatic inspection process, use this information to determine the cause of the defects, and control the manufacturing machinery accordingly, to avoid further defects and improve yield. These functions are explained in Takagi at, for example, col. 5, line 27 to col. 6, line 9 with reference to Fig. 1.

Broude relates to a photolithographic mask (or "reticle") inspection system wherein when a threshold number of reticle defects of a particular size at a particular location is exceeded, the inspection is interrupted and the operator informed, so that time is not wasted continuing inspection of a low-quality reticle (see, e.g., col. 5, lines 47-67). In other words, Broude's system is for efficiently discovering and rejecting reticles that do not meet predetermined quality standards.

Tagaki's purposes would not be furthered by Broude's defect counting and signaling technique. Broude's approach to inspection is much different than Tagaki's, and is used in a different context. Broude's technique is for inspecting completed masks before they are used in production to weed out low-quality masks (i.e., a "go/no-go" test). In contrast, Tagaki improves product yield during production by using defect feature data from the inspection process to improve its inspection process, to determine the cause of the defects, and to adjust the operating parameters of its manufacturing machinery to prevent further defects. None of these functions are performed by Broude's inspection methodology, and none of Tagaki's goals would be served by modifying it with Broude's defect counting and display/inspection shutdown technique. Moreover, there is no objective teaching in Tagaki's yield improvement methodology relating to Broude's functions of defect counting resulting in inspection shutdown, or vice versa. Therefore, a skilled artisan would not have been motivated to add Broude's defect counting and display/inspection shutdown technique to Tagaki's inspection system to yield the invention of

independent claims 1, 18 and 37.

It is contended by the Examiner that a skilled artisan would have been motivated to incorporate Broude's counting and display/shutdown features into Tagaki's inspection system to generate a signal to stop the process to get a better yield. However, there is no support in either reference for this contention. As discussed above, Broude teaches counting defects, displaying the results and shutting down the inspection process to reject a low-quality reticle, not to improve the yield of the reticle manufacturing process (or of any other manufacturing process). Broude's process is not used for in-process inspection, where yield is an issue, but rather is used after completion of a reticle and before production using the reticle begins.

Moreover, stopping or slowing down the process to improve yield is not taught or even suggested as a desirable action in Tagaki. Rather, Tagaki arguably teaches away from such action by teaching the use of its inspection results to determine the causes of defects and to adjust the production parameters accordingly, thereby improving yield. Furthermore, Takagi teaches selecting and segregating defective products for repair by an automatic or manual "repair unit" (see col. 6, lines 39-59). Takagi's production line does not need to be slowed or stopped, as suggested in the Office Action, since Tagaki teaches an alternative technique for dealing with defective products. Such action would defeat the purpose of Tagaki's automated inspection/repair/process control system. It is well-established that if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. ***In re Gordon***, 733 F.2d 900 (Fed.Cir. 1984); ***In re Ratti***, 270 F.2d 810 (CCPA 1959)(If a proposed modification or combination would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious);

MPEP § 2143.01.

The Examiner is using improper hindsight here, using the Applicants' disclosure (of their motivation for making the invention) against them. There is no objective teaching in the art offered in support of the Office Actions' stated motivation to combine the Takagi and Broude references. Furthermore, the cited Shimizu reference does not furnish any such objective teaching either. Indeed, it is not even alleged in the Office Actions that Shimizu furnishes such a teaching. Thus, the statement in the Office Actions offered to show motivation to combine Tagaki and Broude with Shimizu to yield the claimed invention is speculative, and cannot support a rejection under 35 U.S.C. § 103.

Consequently, independent claims 1, 18, 37 and 61-63 are patentable, as are claims 2, 3, 6, 7, 8, 18-20, 23-25, 37, 38 and 40-42, which depend from claims 1, 18 and 37.

Further regarding dependent claims 6, 23 and 41, none of the cited references teaches or suggests the recited feature of claims 6, 23 and 41 of further classifying one of the defects into a variant subclass. It is contended by the Examiner that Takagi teaches this claimed feature at col. 13:7-9; however, this passage of Takagi does not provide support for the Examiner's contention. This passage relates to linking a defect class with a cause, not to further classifying defects that have been classified into subclasses of a particular class, as claimed. Consequently, claims 6, 23 and 41 are further and separately patentable.

b. <u>Claims 35, 36 and 43-45 are not rendered obvious under 35 U.S.C. §103(a) by Tagaki in view of Broude, Shimizu and Shahar, because the Examiner has not shown that all the limitations of their base claims are taught or suggested by the references.</u>

Regarding the obviousness rejection of dependent claims 35, 36 and 43-45 based on Tagaki, Broude, Shimizu and Shahar, the Shahar reference does not furnish a teaching or

suggestion of the important step of independent claims 18 and 37 (from which these claims depend) of classifying each defect into one of a predetermined number of invariant core classes, which step is missing from Tagaki, Broude and Shimizu. Thus, any combination of Tagaki, Broude, Shimizu and Shahar, however made, would be missing this step, and it would not have been obvious to add this step to any Tagaki/Broude/Shimizu/Shahar combination. Moreover, the Shahar reference does not furnish the necessary motivation to combine Tagaki, Broude and Shimizu to yield the computer readable medium of independent claim 18, from which claims 35 and 36 depend, or the apparatus of independent claim 37, from which claims 43-45 depend.

Consequently, claims 35, 36 and 43-45 are patentable.

c. <u>Claims 46 and 47 are not rendered obvious under 35 U.S.C. §103(a) by Tagaki in view of Shahar, because the Examiner has not shown that all the limitations of these claims are taught or suggested by the references.</u>

Regarding the rejection of independent claim 46 based on Tagaki and Shahar, as discussed in detail above, neither of these references teaches or suggests claim 46's important step of classifying each defect into one of a predetermined number of invariant core classes. Furthermore, neither reference teaches or suggests the claimed step of imaging with both an SEM and an optical imager. Takagi teaches optical imaging only, and does not mention SEM imaging or the claimed combination of SEM and optical imaging. See Tagaki col. 15, line 15 et seq. Shahar teaches SEM imaging only. Applicants note that Shahar's detectors 240, 250 are explicitly described as electron detectors, not optical detectors as contended by the Examiner. Moreover, claim 46 requires both optical and SEM *imaging* of a defect, not simply *detecting* light and electron emissions. Shahar does not teach optical imaging, only SEM imaging, so even if its detectors 240, 250 are capable of detecting light, Shahar still does not teach the

SEM/optical imaging step of claim 46, since it does not teach or suggest optical imaging. Since neither reference teaches or suggests the above-discussed SEM/optical imaging step of claim 46, any combination of Tagaki and Shahar, however made, would still be missing this step. Moreover, it would not have been obvious to add this step to any Tagaki/Shahar combination. There is no objective teaching offered to support the Examiner's contention that a skilled artisan would have been motivated to add an SEM to Takagi's apparatus to obtain a better perspective of the image. This contention is speculative and cannot support an obviousness rejection.

Consequently, claim 46 is patentable, as is claim 47, which depends from claim 46.

d. <u>Claim 48 is not rendered obvious under 35 U.S.C. §103(a) by Tagaki in view of Shahar and Tsuchiya, because the Examiner has not shown that all the limitations of its base claim are taught or suggested by the references.</u>

Regarding the obviousness rejection of dependent claim 48 based on Tagaki, Shahar and Tsuchiya, the Tsuchiya reference does not furnish a teaching or suggestion of the important step of imaging with both an SEM and an optical imager of independent claim 46, from which claim 48 depends, missing from Tagaki and Shahar. Thus, any combination of Tagaki, Shahar and Tsuchiya, however made, would still be missing this step, and it would not have been obvious to add this step to any Tagaki/Shahar/Tsuchiya combination.

Consequently, claim 48 is patentable.

IX. SUMMARY

The Examiner's rejections under 35 U.S.C. § 103 do not withstand scrutiny, in that the Examiner has not shown that all the claim limitations are taught or suggested by the references, and has not shown an objective teaching in the art that would have motivated a skilled artisan to combine the cited references to yield the claimed inventions. Appellants, therefore, respectfully submit that the Examiner has not established a prima facie basis to deny patentability to the claimed invention under 35 U.S.C. § 103.

X. PRAYER FOR RELIEF

In view of the foregoing arguments, Appellants respectfully solicit the Honorable Board to reverse the Examiner's rejection of claims 1-3, 6-8, 18-20, 23-25, 35-38, 40-48 and 61-63 under 35 U.S.C. § 103.

To the extent necessary, a petition for an extension of time under 37 CFR 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 12-2237 and please credit any excess fees to such deposit account.

Respectfully submitted,

MCDERMOTT, WILL & EMERY

Michael A. Messina

Michael A. Messina
Registration No. 33,424

600 13th Street, N.W.
Washington, DC 20005-3096
(202) 756-8000 MAM:mcm
Date: April 17, 2003
Facsimile: (202) 756-8087

APPENDIX 1

1. A method of automatically classifying defects on the surface of an article, which method comprises at least:

imaging the surface;

classifing each of the defects as being in one of a predetermined number of invariant core classes of defects;

determining a total number of defects in each of the core classes; and

generating an alarm signal when the total number of defects in a specific one of the core classes is equal to or greater than a first predetermined number.

2. The method according to claim 1, wherein the core classes of defects comprise a missing pattern on the surface, an extra pattern on the surface, a particle on the surface, a particle embedded in the surface, and microscratches on the surface.

3. The method according to claim 1, comprising imaging the surface with a scanning electron microscope.

6. The method according to claim 1, comprising further classifying one of the defects as being in one of an arbitrary number of variant subclasses of at least one of the invariant core classes.

7. The method according to claim 6, comprising

classifying a plurality of defects on the surface of the article; and

determining a total number of defects in each of the subclasses.

8. The method according to claim 7, comprising generating an alarm signal when the total number of defects in a specific one of the subclasses is about equal to or greater than a second predetermined number.

18. A computer-readable medium bearing instructions for automatically classifying defects on the surface of an article, said instructions, when executed, being arranged to cause one or more processors to perform the steps of:

imaging the surface;

classifying each of the defects as being in one of a predetermined number of invariant core classes of defects;

determining a total number of defects in each of the core classes; and

generating an alarm signal when the total number of defects in a specific one of the core classes is about equal to or greater than a first predetermined number

19. The computer-readable medium according to claim 18, wherein the core classes of defects comprise a missing pattern on the surface, an extra pattern on the surface, and a particle on the surface.

20. The computer-readable medium according to claim 18, wherein the instructions, when executed, are arranged to cause the one or more processors to perform the step of imaging the surface with a scanning electron microscope.

23. The computer-readable medium according to claim 18, wherein the instructions, when executed, are arranged to cause the one or more processors to perform the step of classifying one of the defects as being in one of an arbitrary number of subclasses of at least one of the invariant core classes, the subclasses being of arbitrarily defined defects.

24. The computer-readable medium according to claim 23, wherein the instructions, when executed, are arranged to cause the one or more processors to perform the steps of:

classifying a plurality of defects on the surface of the article; and

determining a total number of defects in each of the subclasses.

25. The computer-readable medium according to claim 24, wherein the instructions, when executed, are arranged to cause the one or more processors to perform the step of generating an alarm signal when the total number of defects in a specific one of the subclasses is about equal to or greater than a second predetermined number.

35. The computer-readable medium according to claim 18, wherein the instructions, when executed, are arranged to cause the one or more processors to perform the step of imaging by acquiring a plurality of images using a plurality of spaced-apart detectors.

36. The computer-readable medium according to claim 35, wherein the instructions, when executed, are arranged to cause the one or more processors to acquire the images by causing the detectors to collect electrons.

37. An apparatus for classifying defects on the surface of an article, comprising:

an imager to produce an image of the defect and a reference image;

a storage device to store the defect image and the reference image;

a comparator to compare the defect image and the reference image;

a processor to classify the defect as being in one of a predetermined number of invariant core classes of defects;

a first counter for counting the number of defects in each of the core classes; and

a first signal generator for generating an alarm signal when the total number of defects in a specific one of the core classes is about equal to or greater than a first predetermined number.

38. The apparatus of claim 37, wherein the imager is a scanning electron microscope (SEM).

40. The apparatus of claims 37, wherein the storage device is a digital storage device.

41. The apparatus of claim 37, further comprising of processor for classifying the defect as being in one of arbitrary number of subclasses of at least one of the invariant core classes, the subclasses being of arbitrarily defined defects.

42. The apparatus of claim 41, further comprising a second counter for counting the number of defects in each of the subclasses and a second signal generator for generating an alarm signal when the total number of defects in a specific one of the subclasses is about equal to or

greater than a second predetermined number.

43. The apparatus of claim 38, further comprising a plurality of spaced-apart detectors and a monitor to display images produced by the plurality of detectors.

44. The apparatus of claim 38, wherein the SEM comprises an SEM column, wherein a first one of the plurality of detectors is disposed inside the SEM column and a second one of the plurality of detectors is disposed outside the SEM column.

45. The apparatus of claim 44, further comprising a first monitor for displaying an image produced by the first detector, and a second monitor for displaying an image produced by the second detector.

46. A method of automatically classifying a defect on the surface of an article; which method comprises:

imaging the surface with a scanning electron microscope and an optical imager; and

classifying the defect as being in one of a predetermined number of invariant core classes of defects.

47. The method according to claim 46, wherein the classes of defects include the color of the surface.

48. The method according to claim 46, wherein the surface is glass, and the classes of

defects include a particle embedded in the surface and substantially not protruding from the surface.

61. A method of automatically classifying defects on the surface of an article, which method comprises at least:

imaging the surface; and

classifying each of the defects as being in one of a predetermined number of invariant core classes of defects.

62. A computer-readable medium bearing instructions for automatically classifying defects on the surface of an article, said instructions, when executed, being arranged to cause one or more processors to perform the steps of:

imaging the surface; and

classifying each of the defects as being in one of a predetermined number of invariant core classes of defects.

63. An apparatus for classifying defects on the surface of an article, comprising:

an imager to produce an image of the defect and a reference image;

a storage device to store the defect image and the reference image;

a comparator to compare the defect image and the reference image; and

a processor to classify the defect as being in one of a predetermined number of invariant core classes of defects.